

REMARKS

This application has been carefully reviewed in light of the Office Action dated December 22, 2003. Claims 8 and 42-44 have been amended. Claims 41 and 45-47 have been canceled. Claims 2-5, 8, 10-12, and 42-43 are now pending. Applicants reserve the right to pursue the original claims and other claims in this and other applications. Applicants respectfully request reconsideration of the above-referenced application in light of the amendments and following remarks.

Claims 2-5, 8, 10-12, and 42-45 stand rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement and written description requirements. The rejection is respectfully traversed.

Independent claims 8 and 42-43 have been amended to omit any reference to the pressure of the RTA chamber during wet oxidation. Claims 2-5 and 10-12 depend from claim 8 and are now in full compliance with § 112, first paragraph along with claim 8. Accordingly, Applicants respectfully request that all § 112, first paragraph, rejections be withdrawn.

Claims 2-5, 8, and 10-12 stand rejected under 35 USC § 103(a) as being unpatentable over Patel in view of either Emesh or Chivukula, and further in view of Van Zant. The rejection is respectfully traversed.

The cited references do not teach or suggest “depositing an oxygen-deficient dielectric film; subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450°C, said steam provided in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber, wherein the ratio of hydrogen to oxygen gases in the mixture is in the range of about 0.1 to about 0.8, and wherein the dielectric film undergoes wet oxidation with only a mixture of hydrogen and oxygen gases that form steam,” as recited in claim 8 (emphasis added).

Patel is directed to annealing a ferroelectric layer with an ozone anneal. Patel states, “[o]zone anneals provide a more complete method of supplying oxygen to the ferroelectric material than oxygen anneals since ozone quickly decays to O_2 and O^- .” (Col. 2, lines 11-14). As a result, “ozone is not limited by the same surface adsorption/desorption kinetics as regular O_2 .” (Col. 2, lines 20-22). Another benefit of using ozone over oxygen is ferroelectric material, such as PZT, can “obtain an oxygen atom much quicker than it can obtain one from O_2 .” (Col. 2, lines 28-30). Thus, “ozone can provide a higher concentration of reactive oxygen atoms for diffusion into the ferroelectric material which results in a relatively faster diffusion (penetration) of oxygen into the ferroelectric material. This is important in that the faster oxygen is provided to the ferroelectric crystal, the fewer the number of lead (Pb) atoms that will be lost.” (Col. 2, lines 30-37).

Accordingly, Patel discloses annealing the ferroelectric layer in ozone. Patel does not teach or suggest annealing the ferroelectric layer with a wet oxidation with steam process as claimed by the Applicants. Patel does not teach or suggest only using a mixture of hydrogen and oxygen gases to anneal a dielectric layer. Patel discloses the use of ozone to increase the diffusion of oxygen into the ferroelectric layer. Emesh and Chivukula are relied upon for disclosing the use of a wet oxidation process employing water and ozone to anneal a dielectric film.

Applicants respectfully submit that the combination of Emesh or Chivukula with Patel is improper. In the Office Action dated April 16, 2001, the Examiner acknowledged that “[a]n objective in Emesh is keep the temperature below 500 C during fabrication to keep the thermal budget low which is highly desired in the art (Abstract).” (Office Action, pg. 6). In contrast, Patel teaches that 500°C and above must be used to disassociate the ozone into O_2 and O^- . In particular, Patel states that an “ozone molecule decomposes into an oxygen atom and oxygen molecule in a few milliseconds at 500°C or above. As a result, when a ferroelectric material is expose to ozone, the ferroelectric material can obtain an oxygen atom much quicker than it can obtain one from O_2 .” (Col. 2, lines 24-30). Patel also discloses that the anneal is conducted “at a temperature in the range of about 650°C.

to about 850°C. for about five to thirty seconds.” (Col. 4, lines 11-15). Patel teaches away from an anneal temperature below 500°C. Accordingly, there is no motivation to combine Patel and Emesh. Patel benefits from the use of temperatures higher than 500°C since it quickly disassociates ozone; whereas, Emesh benefits from temperatures lower than 500°C since Emesh’s ferroelectric capacitor can be “placed above low melting point alloys, e.g., aluminum interconnect, in an integrated circuit structure.” (Col. 4, lines 31-33).

The Office Action contends that “Emesh also teaches that increasing the temperature at which oxidation occurs increases the dielectric constant of the high dielectric constant film.” (Office Action, pg. 10). However, Emesh does not teach or suggest this broad of a statement as the Office Action asserts. Emesh merely discloses that “[i]ncreasing the anneal temperature to 500°C, using wet oxygen and the same amount of ozone increase the dielectric constant to 550.” (Col. 8, lines 9-13) (emphasis added). Emesh does not teach or suggest to increase the temperature above 500°C, Emesh merely discloses that temperatures up to 500°C can be used to increase the dielectric constant. There is no teaching or suggestion in Emesh that temperatures above 500°C should be used when the entire reference is directed to a wet oxidation process at a temperature of 500°C and below.

Moreover, Emesh discloses a RTA process at “450°C in an annealing atmosphere comprising oxygen in the presence of water vapour for 300 seconds.” (Col. 5, lines 19-22) (emphasis added). In contrast, Patel discloses a RTA process “conducted at a temperature in the range of about 650°C to about 850°C for about five to thirty seconds.” (Col. 4, lines 11-13). Emesh’s RTA process is ten times longer than Patel’s RTA process. Patel benefits from the fast disassociation of ozone. The combination of Emesh and Patel would destroy the problem that Patel is directed to: increasing the speed of a RTA process to decrease the number of Pb atoms lost during annealing.

Still further, Emesh discloses that when “annealing at 650°C., it is known that Ti from the adhesion layer, and Pb from PZT, may diffuse into the Pt layer . . . [and] may cause an increase in the leakage current,” (Col. 2, lines 60-67), and that “a number of problems occur with integration of PZT and other ferroelectric materials into conventional process flows, many of these problems being related to the relatively high temperature which is required for processing.” (Col. 3, lines 8-14) (emphasis added). Emesh further discloses that its primary focus “was a reduction of the crystallization temperature of the PZT from ~650°C. to <500°C.” (Col. 5, lines 52-54) (emphasis added). Accordingly, there is no motivation to combine Patel and Emesh since Patel teaches an annealing temperature from about 650°C to 850°C.

Similarly, Patel and Chivukula are not properly combinable. Chivukula is directed to providing a “sol-gel precursor solution for formation of a ferroelectric material.” (col. 7, lines 34-35). Chivukula’s sol-gel precursor solution decreases “the carbon content in the bulk of the film.” (Col. 8, lines 14-16). “The sol-gel precursor solution provides particular benefits for processing for integrated circuit applications using rapid thermal annealing at relatively low temperatures.” (Col. 8, lines 22-25). As such, Chivukula’s ferroelectric layer is “annealed by a rapid thermal annealing (RTA) process at above 450°C., and up to 650°C.” (Col. 13, lines 36-40) (emphasis added). In contrast, Patel teaches an annealing temperature of 650°C and above, and thus, there is no motivation to combine Chivukula and Patel.

The Office Action further relies on Van Zant to teach the use of a mixture of hydrogen and oxygen to provide steam, and does not rectify the deficiencies associated with Patel, Emesh, and Chivukula. Moreover, Van Zant teaches that “under the influence of the high temperature,” steam is formed (1st para., page 160) (emphasis added). As discussed previously, Chivukula and Emesh are directed to low temperature processes.

Accordingly, even if the references were combinable as the Office Action asserts, the combination would fail to suggest the invention defined by claim 8. In particular, that the “dielectric film undergoes wet oxidation with only a mixture of hydrogen and oxygen gases that form steam,” as recited in claim 8 (emphasis added). Patel, Emesh, and Chivukula all disclose employing ozone in conjunction with the other oxidation gases.

Claims 2-5 and 10-12 depend from and include all of the limitations of independent claim 8 and are similarly allowable. Withdrawal of the § 103(a) rejection for claims 2-5, 8, and 10-12 is respectfully solicited.

Claim 42 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of either Emesh or Chivukula, and further in view of Ohmi. The rejection is respectfully traversed.

The cited references do not teach or suggest, “depositing an oxygen-deficient dielectric film; subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of only hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450°C and for a duration which increases the oxygen content of the dielectric film, said steam provided in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber,” as recited in claim 42 (emphasis added).

Thus, for at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable and do not teach or suggest “subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of only hydrogen and oxygen gases,” as recited in claim 42 (emphasis added). Ohmi is relied upon for teaching a catalytic system for providing steam for wet oxidation and adds nothing to rectify the deficiencies of the cited references. Accordingly, withdrawal of the § 103(a) rejection is respectfully solicited.

Claim 43 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of the excerpt from Ghandi, and either of Emesh and Chivukula. The rejection is respectfully traversed.

The cited references do not teach or suggest, “depositing an oxygen-deficient dielectric film over an underlying layer; subjecting a non-crystalline dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of from about 450°C to about 750°C, said steam provided in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber,” as recited in claim 43 (emphasis added).

Thus, for at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable since they teach away from each other. Ghandi is relied upon for teaching a pyrogenic system for providing steam for wet oxidation and adds nothing to rectify the deficiencies of the cited references. Moreover, Patel, Emesh, and Chivukula are all directed to the formation of a crystalline perovskite phase of a ferroelectric dielectric material. The cited references do not teach or suggest, “subjecting a non-crystalline dielectric film,” as recited in claim 43 (emphasis added). Accordingly, withdrawal of the § 103(a) rejection is respectfully solicited.

Claim 44 stands rejected under 35 USC § 103(a) as being unpatentable over Patel in view of either of Emesh and Chivukula, and considered with the CRC Handbook of Chemistry and Physics. The rejection is respectfully traversed.

The cited references do not teach or suggest, “depositing an oxygen-deficient dielectric film; subjecting the dielectric film to a wet oxidation with steam process provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature of at least about 450°C and for a duration which increases the oxygen content of the dielectric film, said steam provided in a ratio of at least 0.005 relative to other gases present in the rapid thermal process chamber,” as recited in claim 44.

Thus, for at least the reasons provided above, the cited references Patel, Emesh, and Chivukula are not properly combinable since they teach away from each other. In particular, the references teach different oxidation temperatures. Patel is directed to a high temperature oxidation process i.e., above 500°C; whereas, Emesh and Chivukula disclose an oxidation temperature of below 500°C. The CRC Handbook is relied upon for teaching that steam is present in an amount greater than about 0.005 relative to other gases in the chamber and adds nothing to rectify the deficiencies of the cited references. Accordingly, withdrawal of the § 103(a) rejection is respectfully solicited.

In summary, for all of the reasons set forth above, the cited references, whether considered alone or in combination, fail to disclose or suggest the above-mentioned features of the claimed invention. Allowance of the application with claims 2-5, 8, 10-12, and 42-43 is respectfully solicited.

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Respectfully submitted,

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